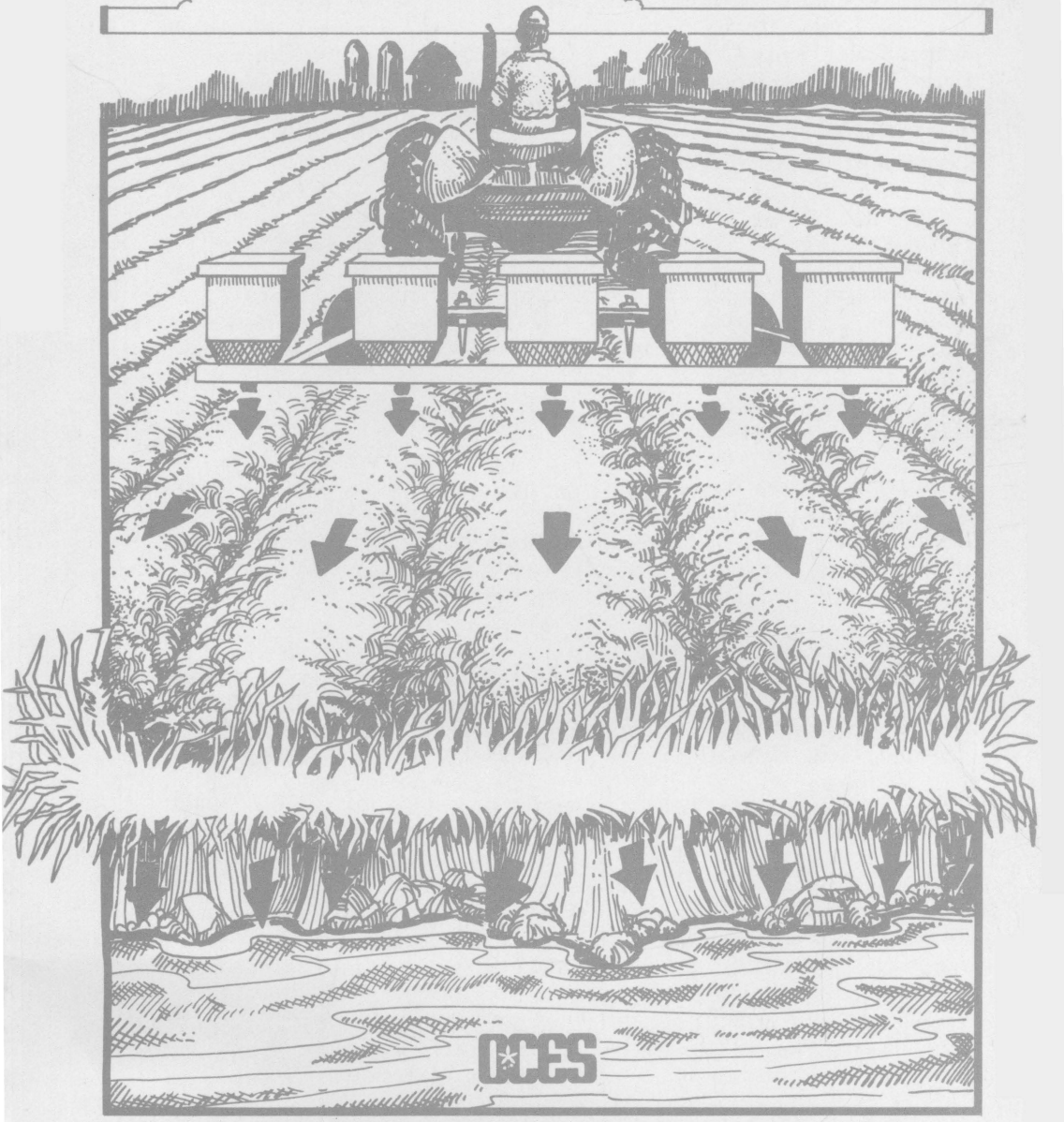
Bulletin 754

Phosphorus Fertilizer Rate Demonstrations

Northwest Ohio (1982-84)



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Phosphorus Fertilizer Rate Demonstrations

Northwest Ohio (1982-84)

Phosphorus rate demonstrations were held in Defiance, Fulton, Hancock, Henry and Van Wert Counties during 1982-84. Thirty-three demonstrations with corn, soybeans and wheat were conducted on soils testing high in available phosphorus during the three-year period.

The demonstrations were conducted to show crop producers that high rates of phosphorus fertilization were no longer needed on many farms in northwest Ohio. Until the 1970s, crop producers found very low available phosphorus soil test levels. Phosphorus fertilizer was applied and yield increases were observed. Crop producers continued to use rates recommended for low testing soils and eventually built soil phosphorus levels to high levels. During the 1970s, crop producers remembering the response to phosphorus fertilization continued the high rates, even though many fields needed only crop removal rates or less.

During the 1970s, high levels of phosphorus in agricultural soils were identified as a major contribution to the high phosphorus loads to Lake Erie, which resulted in accelerated eutrophication of the lake. Communities of major size reduced phosphorus loading from municipal sewage point sources to Lake Erie by 80 to 90 percent. All studies indicated that additional reduction was necessary from non-point sources, which were primarily agricultural. The public began asking crop producers to help lower phosphorus levels in Lake Erie by reducing phosphorus fertilization and soil erosion.

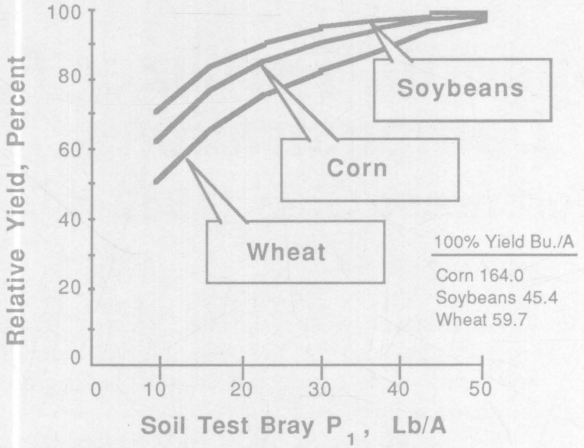
Another reason for crop producers to consider reducing phosphorus rates was to increase net income. Many producers were using rates above those that would provide the highest economic return.

Recommended Phosphorus Rates

Land Grant Universities determine fertilizer recommendations from soil test correlation field research. A soil test is valuable when it can be related to the nutrient rate needed for optimum yield.

Extensive phosphorus soil test correlation research has been conducted throughout the Midwest including Ohio. Ohio along with most states has determined that the Bray P1 phosphorus soil test is the best predictor in the Corn Belt of phosphorus application rate for optimum economic yield. The phosphorus response curves are published in Extension Bulletin 472, Ohio Agronomy Guide, and are shown in Figure 1. These response curves show corn and soybean yields are near optimum at a soil phosphorus test of 30 to 40 pounds per acre. Wheat yields approach 100 percent at 60 pounds per acre. When soil tests are above the 30 pound per acre level for corn and soybeans and 60 pounds per acre for wheat, yield increases are not usually expected from applied phosphorus. With these test levels, the only reason for applying phosphorus is to maintain the

test levels. Research also shows the phosphorus rate needed at low test levels to achieve near optimum yield.



Phosphorus rates recommended in Ohio are based on the research conducted in Ohio which resulted in the crop response curves reported in Figure 1. Recommended rates for corn, soybeans and wheat, as published in the Ohio Agronomy Guide, are presented tin Table 1. Crop removal rates are recommended for corn and soybeans with phosphorus soil tests of 30 to 60 pounds per acre and lower rates are recommended when tests are above 60 pounds per acre. Crop removal rates or less are recommended for wheat when tests are above 60 pounds per acre.

Table 1: Phosphorus rates Recommended for Corn, Soybean and Wheat in Ohio.

Soil Test Value (lb.P/A)	150 bu/A Corn	60 bu/A Soybeans	70 bu/A Wheat
	lb.P_2O_5/A		
10	100	70	115
20	80	60	100
30-60	60	50	75
70	40	40	45
80	20	30	45
90	0	20	45
100	0	0	30

Source: Ohio Agronomy Guide, Ohio Cooperative Extension Service, 1985, Pages 32, 42, 48.

Phosphorus Soil Level and Rates Being Used

The Research and Extension Analytical Laboratory (REAL) at the Ohio Agricultural Research and Development Center (OARDC), located in Wooster, periodically summarizes soil test results by counties. Summary of phosphorus soil tests in the cooperating counties of the study are reported in Table 2. A high percentage of the samples tested 30 pounds per acre or higher and needed very little, if any, applied phosphorus. All samples from Fulton County tests 30 pounds per acre or higher. Henry County had 93 percent of the samples over

30 pounds per acre, Hancock County 85 percent, Van Wert 84 percent and Defiance County 68 percent higher than 30 pounds per acre.

Table 2: Phosphorus soil test summary, 1979

Soil P Level (lb/A)	Defiance	Fulton	Hancock	Henry	Van Wert
	% of samples tested				
< 10	2	9	1	0	0
10-19	14	0	4	1	2
20-29	16	0	10	6	14
30-59	36	5	54	23	59
60-89	11	5	20	27	18
> 89	21	90	11	43	7

Phosphorus use information is hard to find. Ohio data reported by USDA showed an average use of 55.7 pounds P_2O_5 per crop acre in 1981. This is higher than recommended rates for Ohio soils. Average use in Michigan was 46.7 pounds per acre, Indiana 49.2 pounds per acre and Kentucky 48.6 pounds per acre.

A random survey was conducted by Kroetz and Schmidt in 1968 in selected townships in Hancock, Sandusky, Seneca and Wood counties. Information was collected from 113 farms. The average phosphorus rate for corn was 88 pounds P_2O_5 per acre on soil testing 79 lbs available phosphorus available. Ohio recommendations for 150 bushel per acre corn grown on soil testing 80 pounds per acre is 20 lbs P_2O_5 (Table 1). Plant analysis from these 113 farms showed average phosphorus content of 0.36 percent with 0.30 percent considered adequate.

Demonstration Procedures

Cooperators were asked to compare three phosphorus rates on soils with phosphorus tests above 40 pounds per acre. Six of the 33 tests occurred on soils with tests below 40 pounds phosphorus available with the lowest site having a test of 23 pounds per acre. The treatments used were 1) cooperators' normal rate, 2) recommended rate in the Agronomy Guide, which is crop removal or less, and 3) no added phosphorus. While most growers will not use the zero rate, it was included in the demonstration to support research that indicated very little potential of yield increase from phosphorus on corn and soybeans when soil tests are over 30 pounds per acre. If zero phosphorus produces about the same yield as the recommended rate, then growers should have confidence in using recommended rates. Most cooperators' normal rate approximated the recommended rate; therefore, only data from the recommended rate and zero rate are reported.

The demonstrations were designed to be convenient for the cooperator. This resulted in most demonstrations having two variables. The easiest way to get the zero phosphorus rate was to shut off the row fertilizer. Therefore, most of the zero phosphorus treatments also had a difference of row-applied nitrogen and potassium in addition to the effect of row-applied phosphorus fertilizer. This obviously confounded the demonstration as effects of row fertilizer could have been due to any of those elements. Seventeen of the 21 corn demonstrations

and six of the 10 soybean demonstrations had a row fertilizer variable along with the phosphorus rate variable. Plant analysis was used to determine if yield difference was due to phosphorus or another nutrient supplied by row fertilizer. The plots were not replicated and each was about one acre in size. Tissue samples were taken at random from 25 plants in the plot and yields were measured by combine harvesting the entire plot and weighing with a weigh wagon or the grain elevator.

Cooperators were secured and demonstrations supervised by County Extension Agents, agriculture. The District Agronomy Specialist coordinated this program with the Department of Agronomy, The Ohio State University, providing the soil and plant analysis and program guidance.

Results

Twenty-one of the 33 demonstrations were with corn. Results of the corn demonstrations by years are reported in Table 3. There was very little overall yield difference (3.5 bu/A) with or without phosphorus. This small increase in yield from phosphorus would not pay for the cost of the average of 52 pounds P_2O_5 per acre used. The average phosphorus soil test was 94 pounds per acre, well above the response range. These demonstration results agreed with research results showing no response from phsophorus at high test levels. Phosphorus content of the leaf at initial silk was 0.32 percent for both the phosphorus and no phosphorus treatments. The sufficiency level for phosphorus in corn and soybean leaf is 0.3 to 0.5 percent (Ohio Agronomy Guide, 1980).

Table 3: Effect of phosphorus fertilization on corn yield. Means of individual trials.

			Phosphorus			No Phosphorus	
Year	No. of Trials	Bray P_1 Soil Test	P Pertilizer Applied	Yield	Leaf P	Yield	Leaf P
		lb/A	lb P_2O_5/A	bu/A	%	bu/A	%
1982	8	116 (87)*	49	127.3 (27.7)	0.32 (7.1)	124.7 (30.5)	0.33 (9.8)
1983	6	70 (67)	62	105.1 (24.0)	0.33 (8.6)	102.1 (28.3)	0.33 (16.9)
1984	7	88 (113)	47	163.8 (16.0)	0.32 (13.4)	158.7 (14.6)	0.31 (15.0)
MEAN	21	94	52	133.1	0.32	129.6	0.32

* Coefficient of variation (%).

Growers often report a reduction in corn growth when row fertilizer is omitted. This occurred in 11 of the 21 corn demonstrations. In most cases, the growth difference disappeared prior to pollination.

The 3.5 bushel per acre yield difference between phosphorus and no phosphorus was due to a response to row fertilizer at three locations. Further examination of the data, however, raised doubt that this response was due to phosphorus. A no-till location had a 19.9 bushel per acre yield increase from row fertilizer. Plant analysis showed that this yield increase was due to nitrogen and not phosphorus. Two other locations had 16.3 and 12.9 bushel per acre increases from row fertilizer. It appeared from the plant analysis results that potassium and not phosphorus was the problem. Eighteen of the 21 corn demonstration yield comparisons gave differences of 10 bushel per acre or less

(seven showed higher yields without starter), which probably were not significant.

Ten of the 21 corn locations had soil test levels of 60 pounds per acre or lower. Locations with soil test below 60 pounds per acre are compared to those above 60 pounds per acre in Table 4. If yield differences were to occur due to phosphorus, it would be expected to happen at the lower test levels rather than the higher test levels. There was no difference in response at the different test levels, again suggesting phosphorus fertilization had no effect on yield or phosphorus level in the plant.

Table 4: Comparison of corn yield response to phosphorus at low and high soil test levels. Means of individual trials.

			Phosphorus			No Phosphorus	
Soil P Level Lb.P/A	No. of Trials	Bray P_1 Soil Test	P Fertilizer Applied	Yield	Leaf P	Yield	Leaf P
		lb/A	lb P_2O_5/A	bu/A	%	bu/A	%
< 60	10	42 (24.8)*	52	141.6 (28.4)	0.32 (10.8)	138.8 (27.7)	0.31 (12.9)
> 60	11	141 (68.0)	52	125.4 (28.8)	0.32 (10.2)	121.2 (33.1)	0.33 (10.0)

* Coefficient of variation (%).

Soybean yields are reported in Table 5. There was no difference in yield from phosphorus. Early reduction in growth did not occur where phosphorus was not applied. One location showed manganese deficiency later in the growing season in the treatment without row fertilizer.The locations with soil phosphorus levels below 60 pounds per acre had similar results to those above 60 pounds per acre. There were four locations below 60 pounds per acre with an average of 33 pounds per acre resulting in 42.5 bushel per acre while the no phosophorus treatment yielded 43.6 bushel per acre.

Table 5: Effect of phosphorus fertilization on soybean yield. Means of individual trials.

			Phosphorus			No Phosphorus	
Year	No. of Trials	Bray P_1 Soil Test	P Fertilizer Applied	Yield	Leaf P	Yield	Leaf P
		lb/A	lb P_2O_5/A	bu/A	%	bu/A	%
1982	2	182 (83)*	38	47.3 (7.8)	0.52 (10.9)	47.0 (9.9)	0.53 (9.3)
1983	6	76 (39)	43	41.1 (53.3)	0.37 (232)	41.8 (26.7)	0.35 (30.3)
1984	2	66 (27)	27	40.2 (17.6)	0.39 (7.3)	40.4 (7.7)	0.38 (1.8)
MEAN	10	95	39	42.2	0.40	42.6	0.39

* Coefficient of variation (%).

The two locations with wheat provided very limited data. However, the data were what would be predicted. Table 6 reports results of the two wheat tests with a yield increase from phosphorus at the location below optimum phosphorus level for wheat and no effect on yield at the high test location.

Table 6: Effect of phosphorus fertilization on wheat.

County	No. of Trials	Bray P_1 Soil Test	Phosphorus P Fertilizer Applied	Phosphorus Yield	No Phosphorus Yield
		lb/A	lb P_2O_5/A	bu/A	bu/A
Fulton	1	47	36	57.4	43.8
Henry	1	103	39	58.1	61.3
MEAN		75	37	57.7	52.5

Some of the locations were used two or three years in the program with soil test data available after one or two years of no phosphorus. These results are listed in Table 7. The data show the wide variation that can occur in soil test results from year to year reflecting variations that occur primarily from sampling. It appears that not using phosphorus for one or two years has little effect on phosphorus soil test levels. Research at Purdue and other locations has shown that the drawdown of available phosphorus is very slow. The drawdown rate at these yield levels would be about 3 pounds phosphorus per year. At this drawdown rate, it would take about 17 years to reduce the phosphorus test from 90 to 40 pounds per acre as a result of not applying phosphorus.

Table 7: Effect of phosphorus fertilizaton on soil P level.

After	No. of Trials	Beginning P Test	Final P Test With Phosphorus	Final P Test Without Phosphorus
		lb/A		
2 years	6	113	96	107
1 year	7	123	85	105

Summary

This three-year phosphorus demonstration project provided results similar to Ohio's research showing corn and soybean yields do not increase with fertilizer phosphorus when soil phosphorus levels are above 40 pounds per acre. This should increase growers' confidence in using recommendations that call for crop removal rates or less for corn and soybeans when soil phosphorus tests are 30 pounds per acre or higher. Using these recommendations will increase producers' income and, over time, should help to improve water quality of Lake Erie.

Growers should not conclude from these data that row fertilizer should not be used. While the data show that there were no responses from phosphorus and row fertilizer, some growers will be applying maintenance levels of phosphorus. Phosphorus should be placed in the soil rather than on the surface, especially in conservation tillage to avoid build up of phosphorus at the surface, which could result in increased phosphorus leaving the soil in runoff. There are situations where nitrogen is needed in row fertilizer for early growth. With low phosphorus soil test levels, row phosphorus is more efficient than broadcasting. Therefore, row fertilizer is still a good practice and is the perferred method of phosphorus fertilization.